

Citation for published version:

Parry, GC & Roehrich, JK 2012, 'An engineering systems approach to strategic change: The case of the European automotive industry', *Strategic Change*, vol. 21, no. 5-6, pp. 249-262. <https://doi.org/10.1002/jsc.1907>

DOI:

[10.1002/jsc.1907](https://doi.org/10.1002/jsc.1907)

Publication date:

2012

Document Version

Peer reviewed version

[Link to publication](#)

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An Engineering Systems Approach to Strategic Change: The case of the European Automotive Industry

Applying an engineering systems framework of eight lenses to develop strategic transformation in the European automotive industry

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Brief Biographical Notes

Dr Glenn C. Parry is Associate Professor in Strategy and Operations Management at Bristol Business School, University of the West of England. He is also a Visiting Senior Fellow at University of Bath, School of Management. With ten years experience in consulting and academia, he focuses his work within three industrial sectors: Aerospace, Automotive and Music. He was a Theme Leader and Core team member for the EU ILIPT Automotive project and was a leading researcher for the UK Lean Aerospace Initiative and Agile Construction Initiative. His current work involves organisational transformation, focused upon the challenges of the move from product provision to service and value in use through availability contracting. His work formed part of the £2m Support Service Solutions: Strategy and Transition BAE Systems/EPSRC sponsored programme that aims to inform and lead the continuing transformation of the UK economy towards increasing value generation from product related services.

Dr Jens K. Roehrich is Lecturer at the School of Management, University of Bath, UK. His research focuses on the management of long-term inter-organizational relationships, including the dynamic interplay of contracts and trust, inherent in integrated solution provision. Jens' research also explores innovative multi-utility service

provision and value co-creation in urban infrastructure redevelopment projects and investigates innovation in the delivery of health infrastructure projects in Europe. Jens' research has been published or is forthcoming in *Industrial Marketing Management*, *International Journal of Operations and Production Management* and the *Journal of Purchasing and Supply Management*.

Abstract

Build to Order [BTO] refers to a demand driven production approach where the majority of products and components are scheduled and built in response to a confirmed order received for it from a final customer. This paper develops an Engineering Systems approach to strategic adoption of a BTO strategy in the automotive industry. It utilises an Engineering Systems framework which guides overall transformation strategy to realise the vision of building cars at the rate and variety demanded by the customer. However, despite significant investment and research to establish the process and methods required for Build to Order the difficulties in implementing the transformation means the strategic vision has yet to be achieved. Using the eight lenses of Engineering Systems, namely strategy, policy, organization, process, knowledge, IT, products and services, this paper outlines the current and future state of the industry. An expert panel of practitioners and academics were convened to validate and critique both the detail and content of the industry transformation described and the proposed Engineering Systems approach to strategic implementation. Following consultation and amendment the experts agreed and supported both the vision and the Engineer Systems lenses as an approach to change. The study concludes with practical and theoretical implications and questioned whether an additional lens for finance would help to better steer strategic change.

Key Words

Innovation, New Product Development, Build to Order, Lean, Engineering Systems Approach

Focus Areas

Innovation and new product development

Introduction

Enterprise transformation concerns fundamental change that substantially alters an organisation's relationships with its key constituencies, involves new value propositions in terms of product and service, and redefines how the enterprise is organised (Ackoff, 1974; William, 2005). The transformation or 'architecting' of complex large-scale enterprises tends to be explored from a single viewpoint such as IT, process, human resources, but the developing field of scholarship in Engineering Systems provides an integrative holistic approach. From this field, a process described as Enterprise Architecting (Rhodes et al., 2009) offers a systematic framework for the development of holistic strategy development and execution (Richardson, 2008). Working closely with the automotive community and global suppliers, this paper applies this Enterprise Architecting engineering systems approach to the challenge of developing a strategy for the transformation of the European automotive industry. The paper develops a framework strategy to help transform the industry towards adoption of a full Build to Order (BTO) strategy, such that all vehicles can be built and delivered at the rate of demand (Parry and Graves, 2011; Roehrich et al., 2011). BTO is a successful strategy employed in other sectors, for example, within the electronics, companies such as Dell hold stocks of final components and configure them to form products allowing them rapid responsiveness. The variety of components and final products extant in automotive OEMs made such a 'late configuration' strategy initially appear infeasible for the automotive industry (Holweg, 2005). However, a more extensive BTO strategy that extends through the automotive enterprise, integrating suppliers provides a much stronger model upon which car companies could build a sustainable world leading automotive industry (Holweg and Pil, 2004).

Development of innovative Build to Order products and processes requires a significant investment in research and broad access to expert resources. The European Commission recognised the sustainability of the BTO model and the importance of the automotive sector within Europe. The prohibitively high risk and cost associated with developing such an innovative approach to manufacture was too great for a single company to bear, so the EU Commission, in partnership with industry, provided \$23 million to fund this research. It was agreed to set a challenging target of 5 days from order to delivery for the European context, following the completion of a UK only automotive project (3DayCar, 1999-2001). Following completion of the work a validation exercise of the proposed Build to Order strategy showed delivery of 50% of vehicles can be achieved within the five day target time; 97% could be achieved within six days and 100% within eight days. Whilst short of the five day target it exceeds the current industry capability of 40 days (Parry and Graves, 2008).

Despite the significant successes of the project, the adoption of the strategy across the EU has been slow, with only one engine plant adopting a predominantly BTO approach to date. Implementation of such a strategy challenges convention and disrupts established practice and has so far been difficult to implement (Stone et al., 2006). Organisations are compelled to transform to achieve their strategic objectives (Nightingale, 2009). Engineering Systems research focuses upon gaining an understanding of how to transform large-scale enterprises, creating structures which work within their context – a process described as Enterprise Architecting (Rhodes et al., 2009). The term “enterprise” used here is a boundary-defining term to identify a complex system of interconnected and interdependent activities undertaken by a diverse network of stakeholders for the achievement of a common significant purpose (Purchase et al., 2011). Whilst numerous approaches to enterprise architecting are available they are typically oriented towards simpler enterprises than what we find for automotive OEMs (Schekkerman, 2006). For more complex enterprises a broad perspective is needed as complex engineering systems involve tightly coupled parts; changing one component affects many others, leading to unintended consequences. The interactions between them are often highly complex and non-linear (Parry et al., 2010). Complex enterprises are not necessarily based around large firms. Companies choose to outsource functions that are outside their core competencies (Prahalad and Hamel, 1990) and perform only functions that confer competitive advantage (Christiansen and Maltz, 2002). Hence, smaller entrepreneurial firms may also assemble large complex enterprises, drawing together numerous resource providers to deliver service to their market.

In order to structure complex enterprises from a holistic engineering systems perspective, Rhodes et al. (2009) identified eight view points, described as ‘8 lenses’, as vital in building a comprehensive picture. These include: Strategy, which sets the goals, vision and direction of the enterprise, including business model and competitive environment; Policy/ External Factors, which include the external regulatory, political and societal environments in which the enterprise operates; Organization, which includes structure as well as relationships, culture, behaviours, and boundaries between individuals, teams and organizations; Process, which captures the core processes by which the enterprise creates value for its stakeholders; Knowledge, both implicit and tacit which frame capabilities, and intellectual property resident in the enterprise; Information Technology, to include the information needs of the enterprise, including flows of information and systems/technologies for information availability; Products produced by the enterprise for use by its stakeholders; and Services of the enterprise, including services as a primary objective or in support of product. These lenses are arranged in a framework,

with solid lines showing primary and dotted lines secondary relationships, show in figure 1 (Nightingale and Rhodes, 2007).

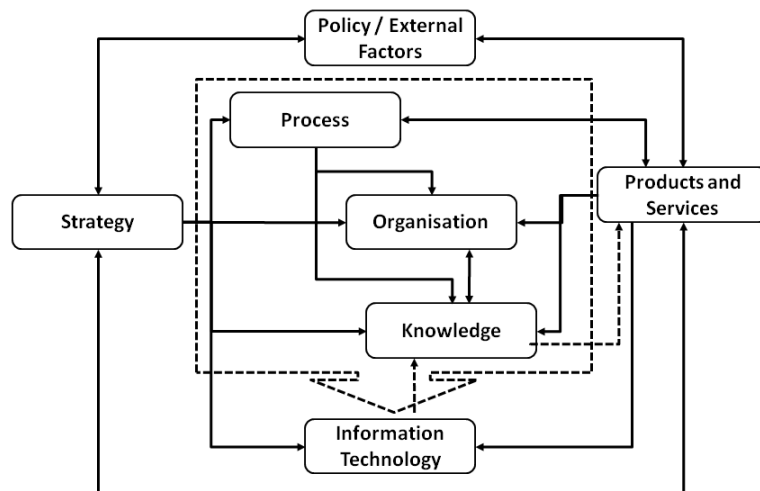


Figure 1. The holistic enterprise architecture framework (adapted from Nightingale and Rhodes, 2007).

The framework is proven to be a useful structure for communication of the approach as well as understanding synergies and interrelationships across views, and has found application in both current and future state enterprise architecting (Sisto, 2010). The remainder of the paper is structured as follows: First, we outline the research methodology employed in the paper. Second, how vehicles may be built to order within 5 days, presented from the perspective of the 8 lenses of engineering systems. Third, a critique of the approach from an expert panel drawn from industry and academia. Finally, we outline conclusions and future work.

Research approach

To explore transformation the approach utilises Epoch-Era Analysis to introduce a temporal element when considering systems in the context of a changing world (Ross and Rhodes, 2008). Eras represent the full lifespan of the system which is decomposed into Epochs. Epochs are defined as time periods when significant needs or context are fixed or the rate of change is slowed creating a plateau of stability with identifiable characteristics along the journey of continuous improvement (Schonberger, 1986; Rhodes et al., 2009). In this work, both current and future state scenarios are identified and defined for each lens, thus creating a time line from present into a possible future.

Two epochs are populated to describe a single transition, from the current, predominantly build-to-stock state to future BTO-dominant state. To populate the information required for the 8 lenses, this paper draws upon the significant body of research undertaken for the ‘Intelligent Logistics for Innovative Product Technologies’ (ILIPT) research programme. This was a pan-European research project representing a vast European effort to develop innovative new concepts to realise Build to Order within the EU automotive industry. To achieve this vision a significant consortium of leading automotive experts was convened from across industry and academia. Project participants were drawn from all over the world. From the automotive industry leading companies including Daimler, BMW, Lear Automotive, Dana Corporation, ThyssenKrupp Steel, Siemens VDO, Saint Gobain Sekurit representing the complete supply chain. Subsequent interactions with the automotive firms in their path towards implementation of a full build to order system have been incorporated. Detail is given of current and future state with required innovations in product and process, as well as potential routes to implementation.

The verification and validation of the work is undertaken using a Delphi style methodology. The work was circulated sequentially to six leading members of the ILIPT programme, representing three senior managers from leading automotive companies and three academic viewpoints. Two iterations of the paper were circulated such that broad agreement was given as to the validity of the structure and strategy. A post-case review of the approach was undertaken based upon the analysis of strategy formulation developed by Platts (1994), which identifies procedure, participation, project management, and point of entry, as desirable characteristics of methodologies. This was undertaken by circulating this paper with a questionnaire to the expert panel. To test the generalisability of the approach, during the post-case review an additional three senior leaders from multinational engineering sector firms outside the automotive sector, representing aerospace, domestic goods, and wind turbine manufacture joined the panel in reviewing this work.

Application of Enterprise Architecture

Table 1 provides an overview of the 8 lens and the transformation from current and future state for each. In this section more detail is provided for each state.

Lens	Current State		Future State
Strategy	Stock push with limited build to order capability and dysfunctional product lifecycles.	→	Full build to order capability

Process	Lean manufacture	→	Lean Enterprise
Organisation	Hierarchical	→	Decentralised
Knowledge	Localised, sequential	→	Expert systems with autonomous agent negotiation
Information Technology	Linear through supply chain	→	Integrated across enterprise
Product	Platform sharing with monocoque chassis. Many shared systems and some modularity	→	Extensive modularity. Body frames separate to styling surfaces
Services	Dealer network hold significant stocks to deliver rapid customer response	→	Dealer network hold very limited 'sample' stock and guide customer order specification
Politics / Environment	Approach has required intervention by governments to prop up system. Overcapacity in business model	→	As systems sustainable; BTO model delivers upon triple bottom line of social, environmental and economic sustainability

Table 1. Overview of transformation from current to future state

Strategy

Strategy: Current State

Many automotive firms offer a Build to Order service, but currently a customer specifying a car has to wait around 40 days to receive their desired vehicle, or alternatively buy one from stock (3DayCar, 1999-2001). To mask the delay, the current automotive strategy is for dealers to hold tens of billions of dollars worth of stock – namely finished cars - to provide the customer with a vehicle which closely matches their specification more quickly. Reported US stock figures between 2006/7 ranged from an average of 25 days for BMW, 85 days for GM and 35 days for Toyota (Automotive News, 2006/7). This enabled companies to find a 'best match' from stock to meet the purchaser's requirement, whilst creating a market for instant gratification. However, customers frequently do not receive what they really want. Incentivised by manufacturer discounts they purchase a vehicle that is a compromise, whilst manufacturers erode their own profits (Holweg and Pil, 2001). It has been proposed that competitive advantage is afforded companies who can provide a product at the right price and quality to the customer within the shortest lead time (Stalk, 1988; Bower and Hout, 1988).

Strategy: Future state

The final customer is a known individual purchaser. Our definition excludes all orders by national sales companies (NSC), car dealers, fleet orders or other supply chain intermediaries. We also exclude the order amendment function, whereby vehicles in production are amended to customer requirements, as this is another level of sophistication for a build to stock (BTS) system. A BTO system does not mean that all suppliers in the supply chain should be producing only when a customer order has been confirmed. Clearly, it would not make economic sense for a manufacturer of windscreen wiper blades to employ BTO. These components should be built to a supplier order, effectively BTS. However, a large expensive item, such as an engine, would be BTO. The point in the supply chain when this BTO/BTS change occurs is called the 'decoupling point' (reference). Part of the challenge for each segment in a supplier network is in the identification of the BTO/BTS boundary; which suppliers should be BTO and which BTS.

Product and Service

Automotive OEMs seek to provide products that address the needs of as many customers as possible, thus providing market coverage. The visual, external differences between vehicles play a significant part of defining their market segment. Internal differences, such as fuel injectors or windscreen wiper motors, are less significant and common parts and modules may be shared across vehicles in many segments. Automotive manufacturers seek to minimise their product part variance, which would drive up cost, and maximise part commonality whilst maintaining an individual product integrity and segment differentiation within the market (Gneiting and Sommer-Dittrich, 2008). Within the ILIPT project we identify the service element of the enterprise as consisting of the dealer network which delivers the product and services it.

Product and Service: Current State

Currently it is the dealers who are a major stock holder for the OEM, and the service provider. A source revealed that of the 114 dealers in the UK, the average stock holding was £1.2million in finished cars. The multiplier effect across the major markets of Europe, China and the US indicates the sums involved run to billions of pounds. A modular approach has already been employed extensively in automotive product design, where great focus has been placed upon common platform strategies (Untiedt, 2008). Here many common parts, including much of the main chassis, are reused over different vehicle variants. However, the current body architectures are monocoque based, with styling surfaces forming part of the load bearing structures. To produce

variation in the appearance of the vehicle, different panels are used across common underpinning platforms which can frequently only be assigned to one product variant [saloon, estate, convertible, hatch back], increasing cost. Colour remains a major variant which adds cost. Coloured parts such as body panels, bumpers and door trims are made of different base materials e.g. plastic, alloys, steel grades and galvanised coatings, which is challenging as different paint types are required to adhere to the material, but must be of the 'same' colour, again introducing cost (Untiedt, 2008).

Product and Service: Future State

Efficient BTO is based on maximising the modular content of product. Modularisation requires extensive collaboration within the automotive enterprise which introduces strong dependencies between firms which research suggested will drive greater collaboration (Howard and Squire, 2007). There were three core aims behind the strategy for the body design: a reduction in production time; a simplification of the order and delivery network facilitating logistics; and a reduction in the required fixed capital within the whole process.

Building on research done by Daimler AG (Truckenbrodt, 2001) a generic vehicle was developed which had a load bearing body structure which was separate from the visual styling surfaces. This concept was used commercially for the BMW Z1, a low volume sports car. The generic body structure followed an approach developed by Daimler AG known as "quartering the car". The vehicle thus comprised a set of four modules: front module which is the primary bumper/impact protection; the engine module which holds the engine and front axle; cabin front, which includes the windscreen and front door area; and the cabin rear which includes the rear seating area, doors, axle and tailgate. By following this approach eight different modules could be combined to produce four different variants of final vehicle: a five-door, three-door, estate/wagon, and convertible. The combination of modules and subcomponents meant that compared to the 5-door base case: the 3-door variant shared 100% parts commonality; the station wagon had 87% commonality; and the convertible 70%. The cost reduction in areas such as complexity, handling, and storage is significant.

Styling surfaces are made from pre-coloured thermo formed plastic panels. These 'clip-on' to the steel body frame chassis to complete the car, removing the need for a paint line at the main vehicle assembly, saving significant time and cost. Whilst not designed to bear substantial mechanical loads, they perform to legislative requirements for crash and impact protection (Gude and Hufenbach, 2008). The commonality in the body frame meant that significant commonality exists across styling surface panels.

A key aim is to remove stock held by car dealers, the key service providers in the value chain. A stockless vehicle supply system removes billions of dollars worth of stock from the service providers and increases their return on capital employed. BTO refocuses the service provider upon aiding customers in choosing their vehicle options and looking after the customers experience through the vehicle life. Car dealerships remain important to the enterprise as it is they who would show the vehicle offering, guide customer choice in vehicle specification and capture customer order data.

Organization

A cornerstone to the proposed transformation to a BTO strategy is the development of collaborative planning and execution. Automotive organizations are already closely linked as current strategies such as 'just in time' delivery requires strong collaborative links and rapid information exchange. Two organizational approaches are discussed with regard to feasibility, the current hierarchical approach and a novel decentralised approach (Fischer and Gneiting, 2008).

Organisation: Current State

A hierarchical organisation, led an original equipment manufacturer (OEM) co-ordinates an entire enterprise, defining the enterprise boundaries and requiring all suppliers to align to their plan. The OEM plans all production quantities, required capacity and warehousing and communicates this to their suppliers. Such an approach functions most effectively with long planning times and stable demand and is similar to the current system in operation for ship building and most car producers who have small build to order volumes. This centralised approach creates organizational tensions as it results in conflicting objectives. An enterprise that is optimised for an OEM limits the efficiency of its suppliers who need to be responsive to that customer. Many automotive suppliers work with more than one OEM and a firm with several customers finds conflicts of interest between allocations of capacity, which can cause individual networks to experience delay. Planned optimisation of a hierarchical network may not be possible as the information required of suppliers can create confidentiality issues. Any changes, such as introducing a new product or a modification of a product, can require a complete renegotiation across the enterprise; an extremely difficult and costly process.

Organisation: Future State

A solution to the issues arising from a hierarchical organisation is the implementation of a decentralised strategy. The assumption underlying this approach is that to be sustainable and feasible, individual firms within

an enterprise must be able to plan for themselves. This planning work depends upon their direct customers and direct suppliers. An enterprise is built up of equal but interdependent partners who are in control of their own planning will work in mutual interest to solve conflicts. This distributes the potential complexity of introducing change across the network. If forthcoming change is communicated to all parties, the required negotiations may happen simultaneously and thus more quickly.

Information Technology

IT: Current State

Currently customer orders received by dealers are passed into national sales channels, regional scheduling, sequencing and purchasing offices within OEMs before the bills of materials are given to the highest level suppliers and passed down supply chains. This significantly contributes to the order delays in the current process. The system is hierarchical and interoperability of systems across the enterprise is generally poor, with integration often limited to the OEM and its major suppliers.

IT: Future State

To achieve BTO in 5-days requires an automated and rapid exchange of relevant data between specific parties in a network. The OEMs need information streams to keep them constantly aware of their suppliers' available and utilised production capacity. Whilst local planning must be undertaken by each plant to optimise the productivity of their internal processes, collaborative planning is undertaken to optimise for the production capacity of the networked enterprise,. Central to achieving the goal of collaboration in planning is the Virtual Order Bank [VOB] (Mandel, 2008). This combines customer demand directly with production capacity throughout the supplier network. The VOB provides a common interface, providing access to information residing in distributed, possibly even heterogeneous, systems. Thus, the VOB acts as a façade to transparently and securely access capacity data, such that the data is still securely kept in possession of the responsible stakeholders on an individual and independent basis. A VOB would give visibility of customer orders, providing data from dealers, OEMS and suppliers and integrating order management and scheduling etc. To protect confidentiality the VOB limits the visibility of data, providing only relevant data to negotiating parties within a framework contract. All BTO partners define their maximum and minimum production capacity, or stock level for BTS suppliers, such that they may remain viable businesses. These maximum and minimum define capacity

‘corridors’ where the trade-off in negotiation is between maximum reliability and a wide corridor, and stability in output with a narrow corridor.

Process

Process: Current State

Current state automotive process exhibits many features of leading practice. The automotive industry has a history of recovery from crisis through development and adoption of leading innovative practice and processes. ‘Lean production’ was documented when the auto industry in the US and European automotive manufacturers set out to employ Japanese automotive best practice and close the productivity gap which had opened up between East and West (Womack et al., 1990). Through rigorous application of lean thinking Western automotive companies implemented process excellence and significantly reduced the productivity gap identified by Womack et al., but none have, as yet, delivered on its heralded promise of zero inventory or just-in-time approach to final customer orders (Stone et al., 2006). Whilst lean has enabled the automotive industry to optimise processes for mass production with minimal waste, it has not tackled the problems of capacity and demand. The industry suffers from global overcapacity and rising stock levels and exhibits inherently low profitability. Following leading practice, a car can be built from flat steel within 11 hours, but a customer specifying a car in a dealership has to wait at best around 40 days to receive their desired vehicle, or alternatively buy one from stock (Miemczyk and Holweg, 2004).

Process: Future State

A shared strategic vision has to be maintained across the automotive enterprise: stocks must be avoided, order to delivery times reduced, queries answered rapidly and planning order data shared rapidly. These elements strongly reflect the lean principles (Womack and Jones, 1996; Liker, 2004). Whilst planning autonomy ultimately remains with production partners, process integration is required to achieve BTO. This is done through the implementation of virtual order banks and autonomous agent negotiation to facilitate the rapid assignments of orders to suppliers (Fisher and Gneiting, 2008).

Pre-negotiation of a supplier’s production capacity maximum and minimum levels, or ‘bandwidth’, along with conditions for temporarily extending or reducing capacity [cost, times etc], is central to the automated collaborative process. Any violations of capacity limits imply that the collaborative plan breaches the agreed

capacity limits set within the supplier network. The automated process seeks to redress the capacity violation. The virtual order bank identifies plants that contribute to the violation and capacity may be re-directed to a plant with spare capacity or a 'capacity agreement add on' initiated, where capacity may be adjusted within a pre-agreed restricted scope and timescale. This process ensures collaborators within the networked enterprise remain economically viable and negates contractual arguments over time, order levels and cost, usual when 'rush jobs' are encountered. This process operates autonomously and hence more quickly than is currently possible, as the current approach would require individuals at OEMs contacting many suppliers and negotiating separate contract amendments. This concept has been trialled and found to be achievable using current IT systems, linked through innovative supporting systems (Fischer et al., 2008).

Knowledge

Knowledge: Current State

Consciously or otherwise OEMs are already employing strategies to attain competitive advantage by co-ordinating suppliers in processes of innovation that recognise their knowledge in delivering customer value (Parry et al., 2010). In current automotive supply chains implementation of Just in Time [JIT], which refers to the movement of material to the right place at the right time, relies on exchange of information and functions through shared knowledge (Wafa et al., 1996). JIT operations are becoming the dominant method of OEM supply service (Von Corswant and Fredriksson, 2002). Whilst there is debate as to the requirement for suppliers to be in close proximity of the OEM for JIT to function (Schonberger and Gilbert, 1983; Dyer and Singh, 1998) JIT capability is linked to the development of knowledge sharing and additional capability development within industry clusters engaged in JIT operations (Saxenian, 1994; Howard et al., 2006).

Knowledge: Future State

A dynamic Build to Order process integrates supply chains and their knowledge base, forming a value creation network (Parolini, 1999). The design of value creation networks considers: logistics strategy, supplier selection, relationships and location. To optimize planning and execution schedules knowledge is necessarily transferred through networks (Leger et al., 2006). The network is efficient when the knowledge transferred is explicit (Grant, 1996). A model of the BTO process and network was created using customer demand data for a current vehicle with the same variants as the ModCar (Toth et al., 2008a). The model required information transparency such that knowledge could be successfully shared across the enterprise (Toth et al., 2008b). This was

challenging as individual firms knowledge needed to be protected from an IP perspective, but shared to facilitate integration. Network design as an independent task determined suitable conditions for planning and execution that ensures that chosen pathways are economically efficient and viable in terms of the knowledge and IP strategy for each individual firm (Chopra and Meindl, 2009).

Politics and Environment

Politics and Environment– current state

The financial crisis of 2008 crippled sales and a lack of availability of capital stilted cash flows. Comparative reported sales for February 2008 and 2009 showed a fall of 41.3% for major US manufacturers, leading analysts to declare an automotive recession (Thompson, 2009). Companies saw an almost doubling of stock level during the worst of the downturn, and there was a suggestion that figures were under reported (Webster, 2006). Reported US stock figures for December 2008 showed significant stock increases with an average of 44 days for BMW, 139 days for GM and 90 days for Toyota (Automotive News, 2008). The reaction of the vehicle OEMs was to halt production, with Honda shutting its UK base for four months (BBC, 2009) and Toyota halting Japanese production for 2 months (Ryall, 2009). Government backed packages incentivised new car purchases, with the \$4 billion US Car Allowance Rebate System (Congressional Budget Office, 2009) and European ‘scrappage schemes’ (Allen, 2009). However, these activities simply supported the current BTS model. German sales rose 40% as a result of the scheme, but shares in automotive OEMs fell as investors were unconvinced that the measures created sustainable change (Reuters, 2009).

Politics and Environment; Future state

Ohno’s vision for Toyota was the building of vehicles at the rate and variety demanded by the customer – building to customer order – such that each vehicle was paid for before it was built (Monden, 1983). Build to Order would provide financial protection to automotive companies and tax payers from market downturns. Similar to the lean approach, the implementation of Build to Order is expected to gain momentum as investors realise the potential of the strategy. The Build to Order approach outlined allows automotive firms to be fully sustainable, achieving the triple bottom line of economic, environmental and societal prosperity (Elkington, 1994). This is achieved and further enhanced by the holistic approach to product development which focuses on production, logistics as well as performance in use. The potential economic impact of Build to Order is the removal of stocks [inventory] throughout supply chain, freeing billions of dollars of cashflow which may be

reinvested in product development. Modular product innovations reduce logistics costs by 45% (Seidel and Huth, 2008). The environmental impact comes from the removal of waste through both unnecessary transport and in the production of unwanted vehicles (Ohno, 1988). The societal impact is founded on the fact that the industry provides more than 12 million skilled jobs and generates \$548 billion in tax revenues across Europe (ACEA, 2009). The Build to Order approach requires that the vehicles are manufactured close to the customer, which would mean that this approach would maintain production and assembly within the major markets, protecting employment and tax revenues and hence bringing benefit to society.

Post Case Review

To explore the viability, validity and generalisability of the proposed approach Platts' (1994) four characteristics for strategy formulation: procedure – the steps taken; participation – who should be involved?; project management - how should the process be organised?; and point of entry - how do we get buy in, when should it be done?. An additional initial question was asked to examine the content of the paper for automotive experts and sufficiency of the eight lenses for the whole panel. The results from the expert panel follow.

Content: Automotive experts made a number of changes to the text of the paper with regards the detail of current and future state before this was agreed. General support and agreement from all the experts was given for the eight lenses, as they were seen to all be necessary for strategy formulation. However, whilst they were all seen as necessary, two experts questioned if they were sufficient. Of particular concern was the role of finance. “...The lenses all seem sensible, but where is finance. Why *isn't that* a lens?”. Follow up discussions were held to explore this concern which centred on the addition of finance as a necessary lens in enterprise architecting. The result was inconclusive as there was a split between the view that finance is tied to the firm level and so responsive to enterprise, and the view that finance is a determinant of enterprise strategy. Further work is required to develop an analysis of finance as an additional lens.

Procedure: The individual steps proposed for the formulation of the enterprise were accepted by all participants and the overall approach was seen as clear. Questions were raised as to the nature of the interaction of the components. Discussions were centred upon how this interaction manifests and if the arrows were too limited, as the ubiquity of a component may differ according to the nature of the enterprise created. “...I think more work may be needed to address the concerns as a ‘*contribution network*’ – for example, hitting one area contributes

to (or enables) hitting another...”. However, in discussion it was proposed that interactions were likely to be context specific. Further work is required to develop experiments to test the interaction and ubiquity of lenses.

Participation: Senior management buy-in was recognised as a necessity for the proposed approach to enterprise architecting, particularly amongst OEM and 1st tier suppliers. Experts proposed the use of workshops to both educate and inform manager from across the enterprise “...*all views through the 8-Lenses* will need to be taught *to increase both the awareness and understanding of the journey to be undertaken...*”. It was noted that field practice frequently differed from documented practice so interviews with senior teams in each area would be required, as well as seeing the activities being performed to ensure understanding of current and future state was captured. Due to the holistic nature, this would require a broader engagement, engaging with and involving more parties than was perhaps usually undertaken. However, this was seen as a strength of the approach as it required an early consideration of multiple aspects of the enterprise which would facilitate significant change such as the transformation to BTO; “...Involvement would be pervasive!”. Further, as the approach comes from a systems engineering perspective the application and language used was seen as more easily acceptable for these domains. “I can see how that would work well in aerospace and I like that its holistic”, “*I’m a systems engineer and strategy from a systems perspective provides good traction for broad application in an engineering environment, we speak the same language*”.

Project management: Automotive experts believed that the established vehicle development project management template used by automotive OEMs was seen as a suitable basis for this work. More generally, the use of either epoch or current and future state was seen as useful in setting and agreeing an underlying chronology for the project. Within this timescale a flexible developmental approach was proposed to facilitate implementation “...one can imagine a six-month rolling plan paradigm where the plans are detailed and beyond the 6-month horizon the plan is less defined but continues to drive towards the goals of the next epoch...”. The resources and timescales were seen as dependent on the nature and size of the business.

Point of entry: Transformation of an industry was recognised as a significant challenge, particularly one as large and conservative as the automotive industry. It was proposed that there was significant inertia in trying to change institutionalised mindset and such a transformation should be undertaken initially in small volume production to demonstrate capability before more widespread application. “...Piloting the approach on a “*small*” project, with a senior manager as a sponsor is probably going to provide the assurance that the CEO would need...”. Such a start point would also allow organisation learning. “...*you* should start with implementing

the new structure on a vehicle with low volumes, just to learn how to make the assembly and logistics physically work. *In this stage there would only be oncost, the benefit comes with expanding to high volume vehicles...*”. It was recognised that the holistic enterprise approach went beyond the firm and the process complexity and its coverage of multiple companies would only create benefit by active collaboration. Hence, it is not down to a single stakeholder, but a number who must agree on their willingness for transformation. Compelling evidence would be required to co-ordinate and initiate change across multiple firms and here the approach was seen as beneficial. “...Getting it started would require a well constructed business case; this is where the 8-lense view appears to be extremely useful..”.

Conclusions and Implications

This paper presents the development of an Enterprise Architecting approach to strategy formulation in the European automotive industry. The original lean vision of building vehicles at the rate and variety demanded by the customer has not yet been achieved. Lean has improved productivity, but not yet achieved BTO. Similar to the lean approach, the implementation of Build to Order is expected to have a slow start but rapidly gain momentum as investors realise the potential of the strategy. Through addressing three of the seven wastes within automotive production identified by Taiichi Ohno, namely overproduction, unnecessary transportation and inventory (Ohno, 1988), the Build to Order approach outlined allows automotive firms to be fully sustainable, achieving the triple bottom line of economic, environmental and societal prosperity.

The case for adoption of a Build to Order strategy is strong and implementation has already begun within some of the OEMs of the European industry. Initially adoption is targeted upon low volume vehicles, in line with comments from the expert panel. Early adoption is challenging, but the longer term benefits of a transition to the new paradigm bring the potential for longer term sustainable competitive advantage. The 8 lenses of strategy formulation were recognised as necessary and useful in undertaking enterprise transformation on the scale required for BTO. The language of engineering systems was seen to make the enterprise approach more accessible to the multiple domains engaged, thus facilitating buy-in.

Further work was identified in two areas. First, work is required to test the potential of including finance as an additional lens. Second, the development of experiments to test the interaction and ubiquity of lenses such that their relationships may be better understood.

Acknowledgement

We would like to acknowledge the support of the European Commission and ILIPT industry partners who funded the research. We thank our expert panel who contributed their views and helped to shape the work.

References

3DayCar, (1999-2001). Available online: <http://www.3daycar.com/>

ACEA, European Automobile Manufacturers Association. Available online: <http://www.acea.be/index.php/collection/statistics>.

Ackoff R.L. 1974. Redesigning the future: A systems approach to societal problems, New York: John Wiley.

Allen P. 2009. Budget 2009 – car scrappage schemes across Europe, guardian.co.uk, Wednesday 22 April 2009

Automotive News, (2006-8). Available online: <http://www.autonews.com/>

BBC News, Honda's four-month break begins, (1st February 2009). Available online: <http://news.bbc.co.uk/1/hi/business/7859863.stm>.

Bower J.L., Hout, T.M. 1988. Fast-cycle capability for competitive power. *Harvard Business Review*, 66(6): 110-88.

Chopra S., Meindl P 2009. Supply Chain Management – Strategy, Planning and Operation. 2nd Edition, Pearson Education .

Christiansen P.E., Maltz A. 2002. Becoming an “interesting” customer: procurement strategies for buyers without leverage. *International Journal of Logistics: Research and Applications*, 5 (2): 177-194.

Congressional Budget Office (2009). H.R. 2751: Consumer Assistance to Recycle and Save Act. Available: <http://www.cbo.gov/ftpdocs/103xx/doc10323/hr2751.pdf>

Dyer, J.H. Singh, H. 1998. The relational view: cooperative strategy and sources of interorganizational competitive advantage. *Academy of Management Review*, 24(4): 660–679.

Elkington J. 1994. Towards the sustainable corporation: Win-win-win business strategies for sustainable development. *California Management Review*, 36(2): 90-100.

Fischer J.-G. Gneiting P. 2008 Collaborative Planning Processes. In Glenn C. Parry and Andrew P. Graves, (eds) Build to Order: The Road to the 5-day Car, Springer, Chapter 11, pp 181-207.

Fischer J.G., Withaut M., Berger M. 2008. Functionalities of supporting IT systems: current situation, future requirements and innovative approaches. In Parry, G. and Graves, A. Eds Build to Order: The Road to the 5-day Car, Springer, Chapter 13, pp 223-237.

Gneiting P., Sommer-Dittrich T 2008. An overview of modular car architecture: the OEMs perspective on why and how. In Glenn C. Parry and Andrew P. Graves, ed's Build to Order: The Road to the 5-day Car, Springer Chapter 6, pp 13-34.

Grant R.M. (1996). Toward a knowledge based theory of the firm. Strategic Management Journal, 17: 109-122.

Gude M., Hufenbach W 2008. Modular Concepts and the design of the ModCar body shell. In Glenn C. Parry and Andrew P. Graves, ed's Build to Order: The Road to the 5-day Car, Springer Chapter 7, pp 133-153.

Holweg M. and Pil F.K. 2001. Successful Build-to-Order Strategies Start with the Customer. MIT Sloan Management Review, 43(1): 74-83.

Holweg M. and Pil F.K. 2004., The second century: Reconnecting customer and value chain through build-to-order; moving beyond mass and lean production in the auto industry. Boston, Massachusetts: MIT Press .

Howard M., Miemczyk J., Graves, A. 2006. Automotive supplier parks: An imperative for build-to-order? Journal of Purchasing & Supply Management, 12(2): 91-104.

Howard, M. Squire B. 2007 Modularization and the impact on supply relationships. International Journal of Operations and Production Management, 27(11): 1192-1212.

Leger P.M., Cassivari L., Hadaya P., Caya O. 2006. Safeguarding mechanisms in a supply chain network. Industrial Management and Data Systems, 106(2):208-222.

Leseure M., Birdi K., Bauer J., Denyer D., Neely A. 2004. Adoption of promising practice: a systematic review of the evidence, report for AIM [Advanced Institute of Management], (February 2004). Available online: <http://www.aimresearch.org>.

Liker J. K. 2004. *The Toyota Way: 14 Management Principles from the world's greatest manufacturer* McGraw-Hill.

Mandel J. 2008 Collaborative Execution Processes. In Glenn C. Parry and Andrew P. Graves, ed's Build to Order: The Road to the 5-day Car, Springer ,Chapter 12, pp 209-221.

Miemczyk J.,Holweg M. 2004. Building cars to customer order-what does it mean for inbound logistics operations. Journal of Business Logistics, 25(2): 171–197.

Monden Y. 1983. Toyota production system – practical approach to production management. Industrial Engineering and Management Press.

Ng I., Parry G., Wilde P., McFarlane D. 2011. Complex Engineering Service Systems: Concepts and Research. London: Springer.

Nightingale D. 2009. Principles of Enterprise Systems”, Second International Symposium on Engineering Systems. MIT, Cambridge, Massachusetts. Ohno T. 1988. Toyota Production System. Productivity Press.

Parry G. C., Graves A.P. 2008 Build to Order: The Road to the 5-day Car. London: Springer.

Parry G., Mills J., Turner C. 2010. Lean competence: integration of theories in operations management practice. Supply Chain Management: An International Journal, 15(3): 216-226.

Parolini C.1999. The Value Net: A Tool for Competitive Strategy. John Wiley & Sons.

Persson F., Olhager J. 2002. Performance simulation of supply chain designs. International Journal of Production Economics, 77(33): 231-245.

Prahalad C.K., Hamel G. 1990. The core competence of the corporation. Harvard Business Review, 68(3): 79-91.

Purchase V., Parry G., Valerdi R., Nightingale D., Mills J. 2011. Enterprise Transformation: why are we interested in it and what are the challenges?, Journal of Enterprise Transformation, 1:14–33.

Reuters 2009. UPDATE 2-German May car sales up 40 pct on tax 'steroids', Reuters, (Wednesday Jun 3rd 2009). Available online: <http://www.reuters.com/article/idUSL347499620090603>

Rhodes D., Ross A., Nightingale D. 2009. Architecting the System of Systems Enterprise: Enabling Constructs and Methods from the Field of Engineering Systems” IEEE SysCon 2009 —3rd Annual IEEE International Systems Conference, Vancouver, Canada, March 23–26.

Richardson J. 2008. The business model; an integrative framework for strategy execution. *Strategic Change*, 17: 133-144.

Roehrich J., Parry G., Graves A. 2011. Innovation in inter-firm networks: The Build-to-Order paradigm. *International Journal of Automotive and Technology Management*, 11(3): 221-235.

Ross A., Rhodes D. 2008 Using natural value-centric time scales for conceptualizing system timelines through epoch-era analysis. 2008 Symposium of the International Council on Systems Engineering (INCOSE), Utrecht, Netherlands, June 16–20.

Ryall J. 2009. Toyota to halt Japanese production in February and March. *Telegraph.co.uk*, (Tuesday January 6th 2009). Available online: <http://www.telegraph.co.uk/finance/newsbysector/transport/4139865/Toyota-to-halt-Japanese-production-in-February-and-March.html>

Saxenian A. 1994. *Regional Advantage*. Cambridge, MA: Harvard University Press.

Schonberger R.J., Gilbert J.P. 1983. Just-in-time purchasing: a challenge for US industry. *California Management Review*, 26(1): 54–68.

Seidel T., Huth T. 2008. How the electro-mechanical valve train accelerates logistics and reduces costs. In Glenn C. Parry and Andrew P. Graves, ed's *Build to Order: The Road to the 5-day Car*, Springer Chapter 18, pp. 311-322.

Schekkerman J. 2006. *How to Survive in the Jungle of Enterprise Architecture Frameworks: Creating or Choosing an Enterprise Architecture Framework*. 3rd Edition, NC: Trafford .

Schonberger R.J. 2007. *Best Practices in Lean Six Sigma Process Improvement*. Wiley.

Sisto G.A. 2010. *Assessing Stakeholder Salience through the View of Lean Enterprise Transformation*, MSc Dissertation MIT Department of Aeronautics and Astronautics. Available online: <http://lean.mit.edu/docman/2010-theses/view-category.html>

Stalk G. Jr. 1988. Time – the next source of competitive advantage. *Harvard Business Review*, 66(4): 41-51.

Stone G., Parry G.C., Graves A.P. 2006. Transformation of the European automotive industry, the future of lean. *International Journal of Financial Transformation*, 18:10-15.

Thompson C. 2009. GM, Ford plunge as U.S. sales drop 41.3%. Automotive News Europe, (March 3rd 2009).
Available online: [http:// www.autonews.com/article/20090303/ANA05/903039928/1078/COPY01](http://www.autonews.com/article/20090303/ANA05/903039928/1078/COPY01)

Toth M., Mandel J., Ost S., Dürr, P. 2008b. D 8.6.2: Validated Digital Evaluation Platform, ILIPT report D8.6.2 for the EU Commission (April 30th 2008b).

Toth M., Seidel T, Klingebiel K. 2008. Moving towards BTO – an engine case study. In: Glenn C. Parry and Andrew P. Graves, ed's Build to Order: The Road to the 5-day Car, Springer, Chapter 17, pp 297-310.

Truckenbrodt A. 2001. Modularized Cars – die Quadratur des Autos. Verkehrswissenschaftliche Tage, Dresden, (2001).

Untiedt A. 2008. The Modular Body. In: Glenn C. Parry and Andrew P. Graves, ed's Build to Order: The Road to the 5-day Car, Springer, Chapter 7, pp. 109-132.

Von Corswant F., Fredriksson P. 2002. Sourcing trends in the car industry. International Journal of Operations & Production Management, 22(7): 741–758.

Wafa M.A., Yasin M.M., Swinehart K. 1996. The impact of supplier proximity in JIT success: an informational perspective. International Journal of Physical Distribution and Logistics Management, 26(4): 23–34.

Webster S.A. (2006) . Top dealer says there are more unsold cars than reported”, Detroit Free Press (Online), (2006) 26th October.

William B.R. 2005. A Theory of Enterprise Transformation. Systems Engineering, 8(4): .

Womac, J.P. Jones D.T., Roos D. 1990. The Machine That Changed the World, Rawson Associates.

Womack J.P. , Jones D.T. 1996. Lean Thinking: Banish Waste and Create Wealth for Your. Corporation, Simon & Schuster.